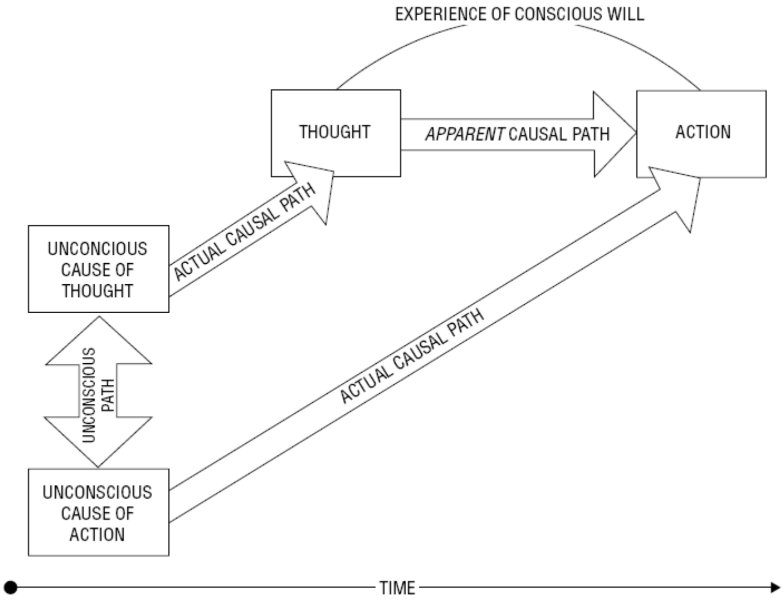
# Thought Question

- How might the authorship model explain the development of “automatic” processing? That is, according to this model, what is likely to be changing as a process becomes automatic? How does this differ from the more standard view of automaticity?

# Authorship model

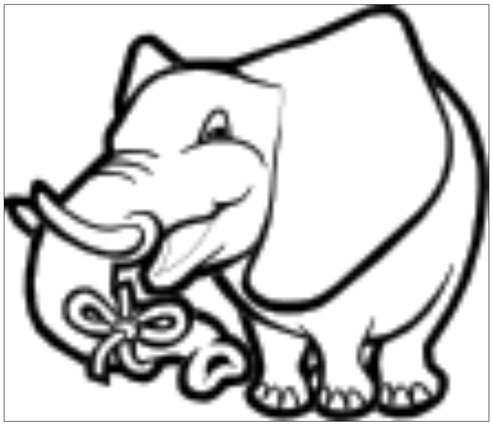


| **Automatic (unconscious)** | **Controlled (conscious)** |
|---|---|
| Uses few (if any) attentional resources | Uses attentional resources |
| Rapid (one second or less) | Relatively slow (several seconds) |
| Without intention | With intention |
| Can’t introspect about | Can introspect about |
| **Inflexible** | **Flexible** |

# Conclusions

- Consciousness is an important way that the brain deals with novel, challenging, informative events.
- Conscious experience accesses many knowledge sources.
- Creates coherent perceptions and controls actions.
- Important for self-monitoring and self-reflection.

# Short-Term Memory



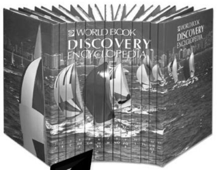
---

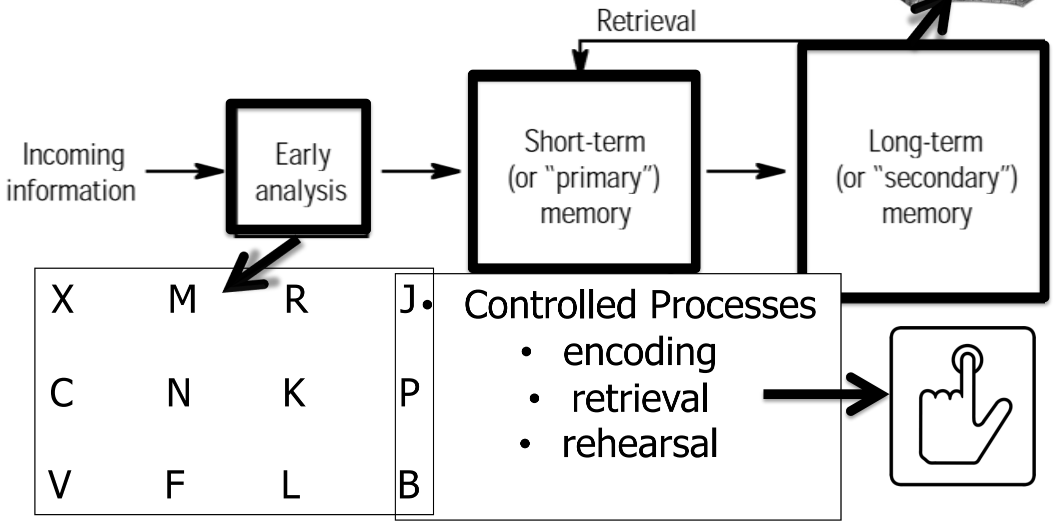
# Time

| 1-5 seconds | 1 minute | hours to years |
|---|---|---|
| SENSORY MEMORY | SHORT-TERM MEMORY | LONG-TERM MEMORY |

# 3-store (modal) model

## (Atkinson & Shiffrin)





Retrieval

Incoming information

Early analysis

Short-term (or "primary") memory

Long-term (or "secondary") memory

| | | | |
|---|---|---|---|
| X | M | R | J |
| C | N | K | P |
| V | F | L | B |

Controlled Processes
- encoding
- retrieval
- rehearsal

# Questions about STM

- What is its capacity?
- How is information lost from STM?
- How is information coded (represented)? Are there multiple STMs?

# Questions about STM

- What is its capacity?
- How is information lost from STM?
- How is information coded (represented)? Are there multiple STMs?

---

# Capacity

- "Digit span" test

5 2 7

8 1 3 9 1

7 3 8 6 9 8 1

2 5 1 9 2 4 7 5 3

9 6 2 8 1 5 8 2 9 3 7

# Capacity

- George Miller's "Magical Number Seven"

This is perhaps the most famous article in all of cognitive psychology. The opening lines:

*My problem is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data, and has assaulted me from the pages of our most public journals. This number assumes a variety of disguises, being sometimes a little larger and sometimes a little smaller than usual, but never changing so much as to be unrecognizable. The persistence with which this number plagues me is far more than a random accident. There is, to quote a famous senator, a design behind it, some pattern governing its appearances. Either there really is something unusual about the number or else I am suffering from delusions of persecution*.

---

# Capacity

- George Miller's "Magical Number Seven"
- People seem to be able to hold onto 7 (+/- 2) items in short-term memory

- What counts as an item?

# Chunking

16 items:  1492177619842002

4 items:

1492
1776
1984
2002

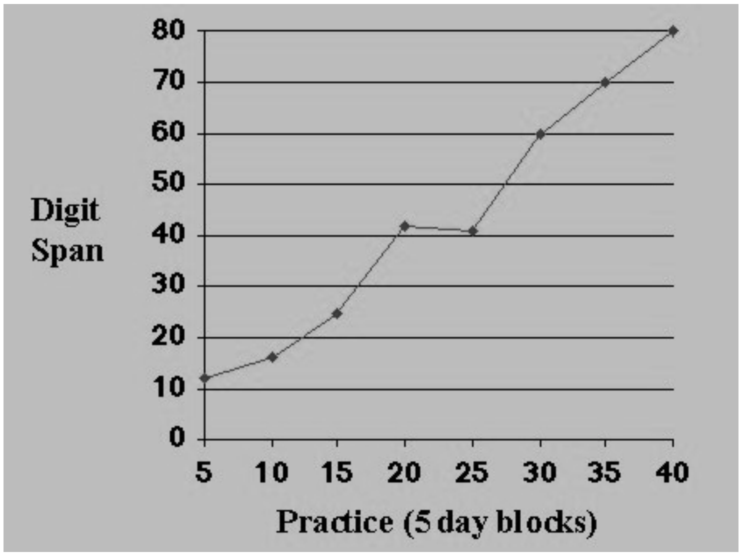
---

# Chunking

- Process of “recoding” information
- Depends on knowledge

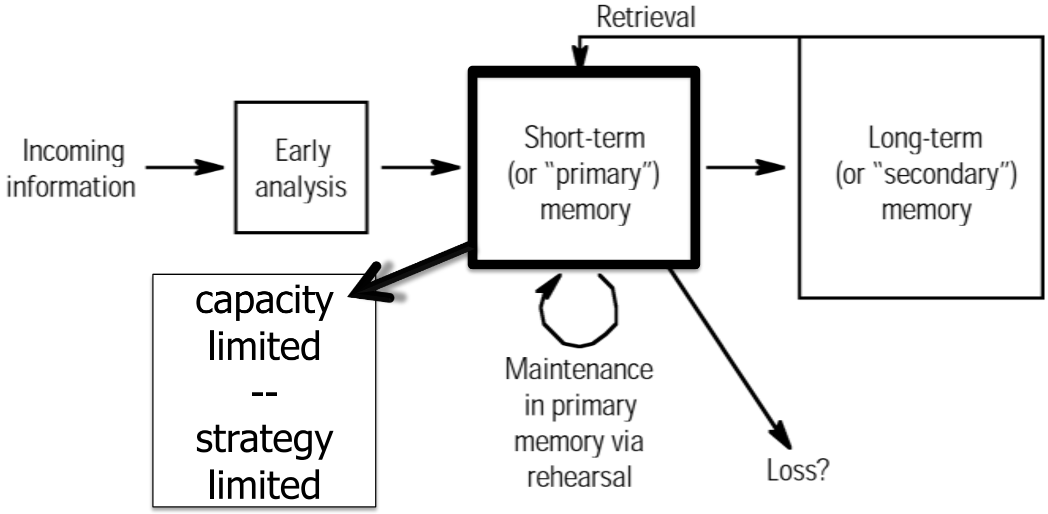
- Powerful means for functionally increasing memory capacity

# The Power of Chunking



# 3-store (modal) model

## (Atkinson & Shiffrin)


Retrieval
Incoming information
Early analysis
Short-term (or "primary") memory
Long-term (or "secondary") memory
Maintenance in primary memory via rehearsal
Loss?

capacity
limited
--
strategy
limited

# Questions about STM

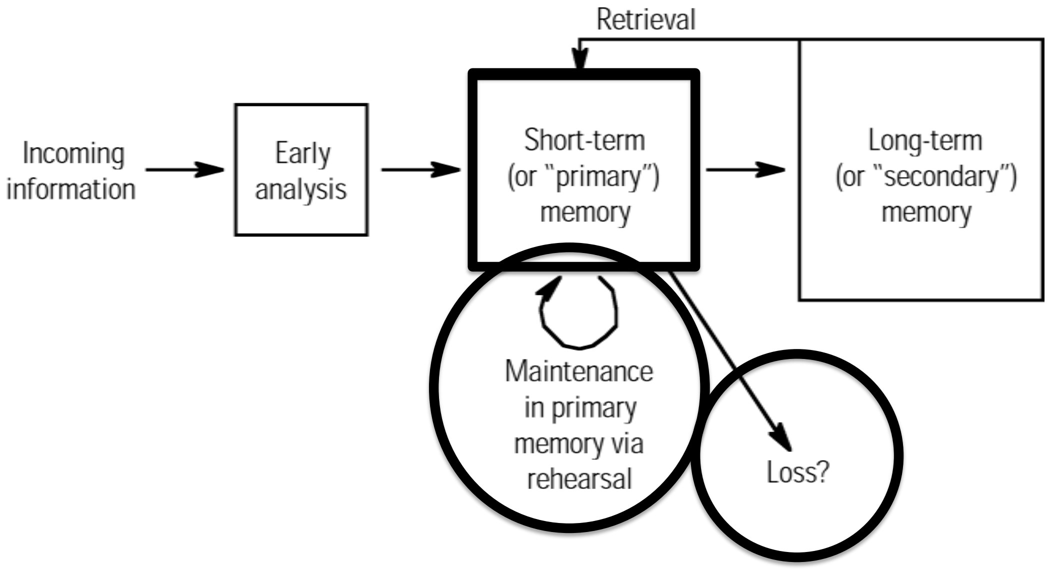
- What is its capacity?
  - 7 items
  - …where an item is a “chunk” of information
  - …and amount of information dependent on strategy
- How is information lost from STM?
- How is information coded (represented)?
- Are there multiple STMs?

# Questions about STM

- What is its capacity?
- How is information lost from STM?
- How is information coded (represented)?
  Are there multiple STMs?

# 3-store (modal) model

(Atkinson & Shiffrin)


Retrieval
Incoming information
Early analysis
Short-term (or "primary") memory
Long-term (or "secondary") memory
Maintenance in primary memory via rehearsal
Loss?

# Information loss

- **Hypothesis**: Failure to rehearse causes LOSS
- Brown-Peterson task:
  - get three letters to remember
  - get a number
  - must count backwards (out loud) by threes from that number until cued to recall
    - this prevents people from rehearsing
    - can vary *how long* participants have to count

# Information loss

- with FILLED DELAY, only 7% of people can recall the three letters after 20 seconds

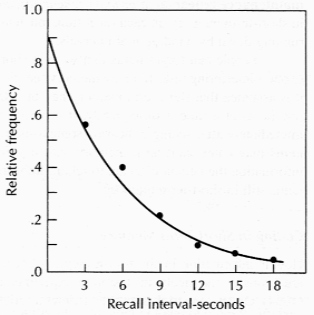
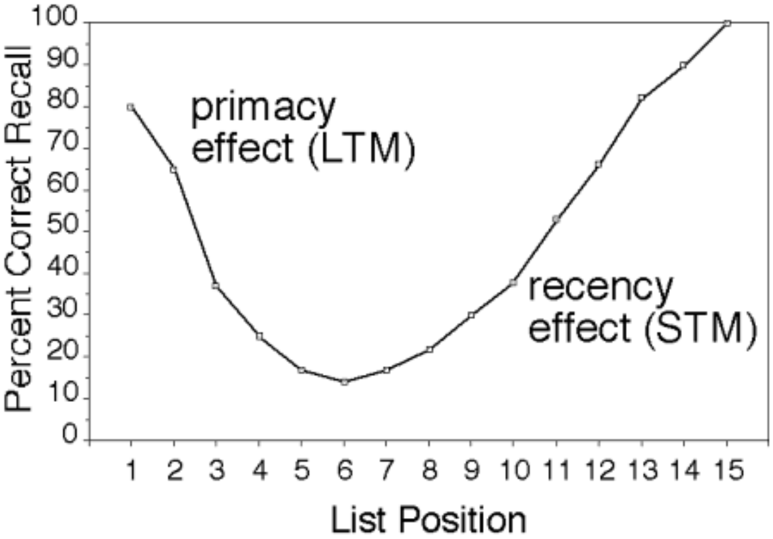


**Figure 5.1** Proportion recalled in short-term memory task as a function of delay during which subjects are counting backward by 3.

Source: Peterson, L. R., & Peterson, M. J., 1959.

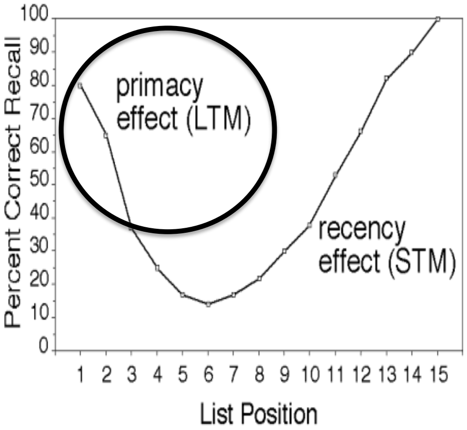
# The Serial Position Curve

# The Serial Position Curve



# Primacy Effect

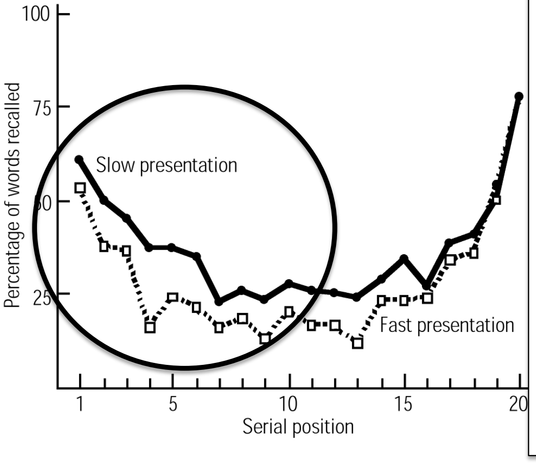
Serial Position Curve



- Better memory for first items. Why?
  - more time to rehearse first words

# Primacy Effect

Serial Position Curve



Rate Manipulation:

..train…..teacup…..kitchen

vs.

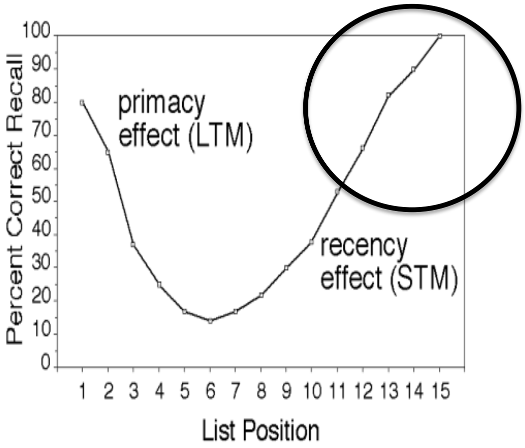
train teacup kitchen

--recall--

---

# Recency Effect

Serial Position Curve



- Better memory for recent items. Why?
  - absence of decay
  - words still in STM

# Questions about STM

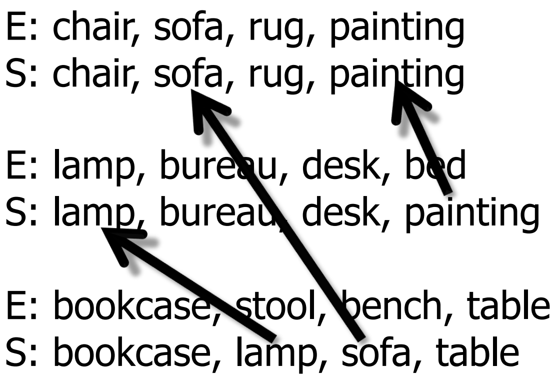
- What is its capacity?
- How is information lost from STM?
  - inability to rehearse
- How is information coded (represented)?
- Are there multiple STMs?

---

# Information loss

- **Hypothesis**: Interference from other items causes recall ERRORS
  - proactive interference
  - retroactive interference

# Proactive interference



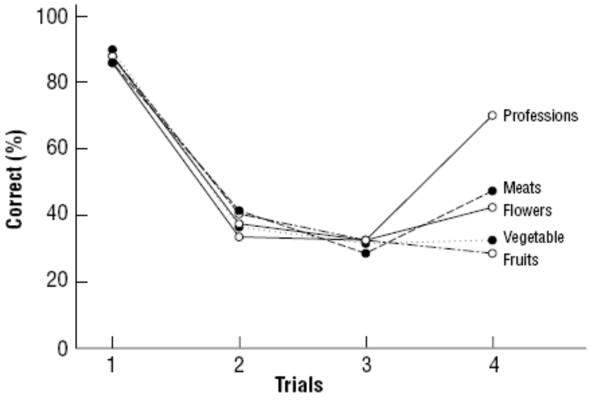
E: chair, sofa, rug, painting
S: chair, sofa, rug, painting

E: lamp, bureau, desk, bed
S: lamp, bureau, desk, painting

E: bookcase, stool, bench, table
S: bookcase, lamp, sofa, table

- Older material interferes with recollection of current material.
- Occurs when you are learning many similar things.

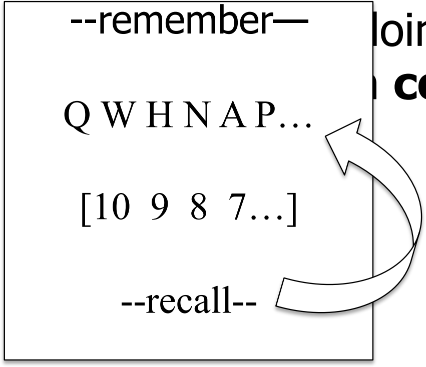
# Release from Proactive interference



- Proactive interference builds up as similar information must be learned.
- When type of information changes, performance suddenly returns to initial levels.
- Suggests merit of rotating material across a learning session.

# Retroactive interference

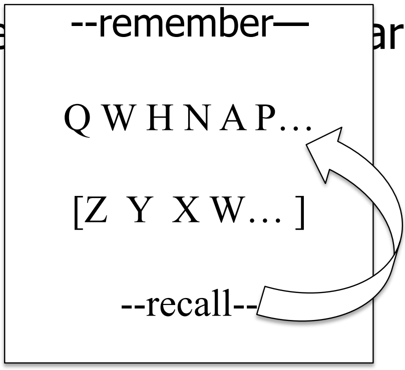
- Interference from **new** material to **old**.
- Example:
  - letters forgotten faster when distractor
    loing the ards
    **counti**


--remember—

Q W H N A P…

[10 9 8 7…]

--recall--


--remember—

Q W H N A P…

[Z Y X W… ]

--recall--

# Questions about STM

- What is its capacity?
- How is information lost from STM?
  - inability to rehearse
  - interference (proactive and retroactive)
- How is information coded (represented)?
- Are there multiple STMs?

# Questions about STM

- What is its capacity?
- How is information lost from STM?
- How is information coded (represented)? Are there multiple STMs?

# Word Length Effect

# Word Length Effect

- Box
- End
- Cub
- Wit
- Black
- Rose
- Dog

- Technology
- Encyclopedia
- Conventional
- University
- Establishment
- Stereophonic
- Pictorial

---

# Word Length Effect

- Chad
- Burma
- Greece
- Cuba
- Malta
- 4.17/5

- Czecholslovakia
- Somaliland
- Nicaragua
- Afghanistan
- Yugoslavia
- 2.8/5

# Word Length Effect

- So capacity of memory NOT just a function of number of items.
- Memory span varies closely with *pronunciation time* (how long it takes to read items aloud).
- Capacity has been argued to be amount you can pronounce in 1.5 seconds.

- Suggests that STM is phonological.

# More evidence

- People asked to remember HBKLMW.
- What kind of mistakes do they make?
  - likely to substitute a similar *sounding* letter, such as “V” for “B”
  - more true for auditory presentation, but also with visual presentation

- Suggests people are using a phonological representation (code).

# BUT . . .

- What about Deaf individuals?
- As might be predicted, results showed *visual* confusability (e.g., R and B).

- So STM representations don't HAVE to be phonological.

# Shift toward "Working Memory"

- Baddeley and Hitch (1974) argued that short-term memory (now called "Working Memory") involves more than simply storage of information. Instead:
- Working memory involves:
  - Storage
  - Processing
- It is called working memory because it is a form of memory that does more than just store information– it manipulates and analyzes it too

# Working Memory Model

- Architecture of Working-Memory Model
- What was simply a STM store now includes:
  - Central Executive system
  - Subsystems:
    - Visuospatial scratch pad
    - Phonological rehearsal loop

acoustic and verbal information

visual and spatial information

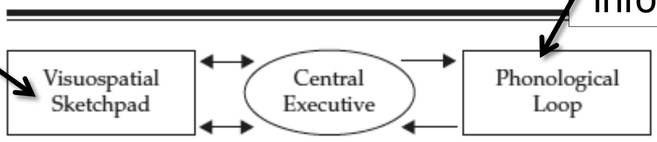
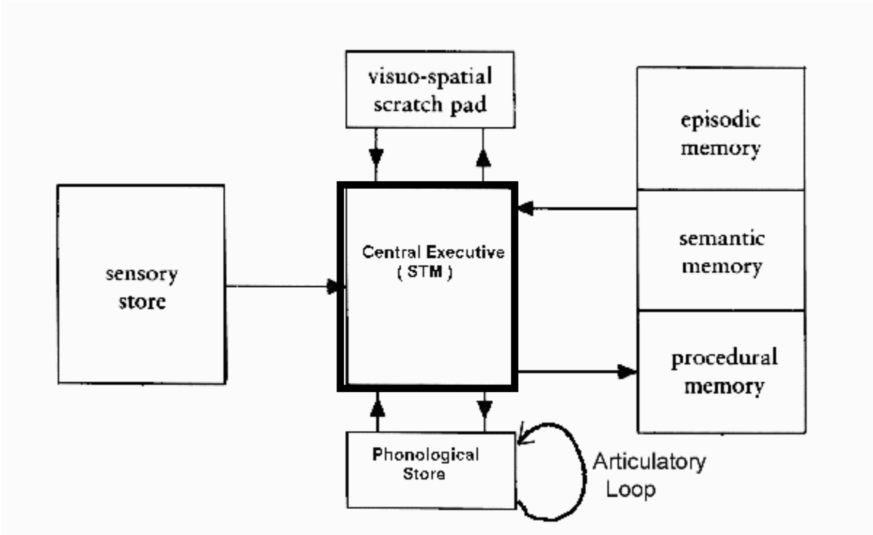


**Figure 1**
The model of working memory proposed by Baddeley and Hitch (1974).

# … all together



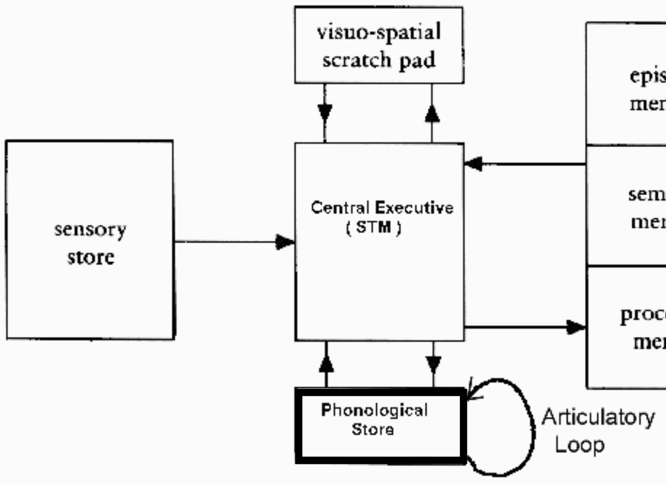
Baddeley’s Working Memory Model

# Central Executive

- Limited capacity
- Various functions
  - coordinate access to long-term memory from sensory inputs
  - allocate information to the secondary systems (phonological store and sketchpad)
- Important for
  - Resource allocation
  - Trouble-shooting
  - Planning, decision-making

---

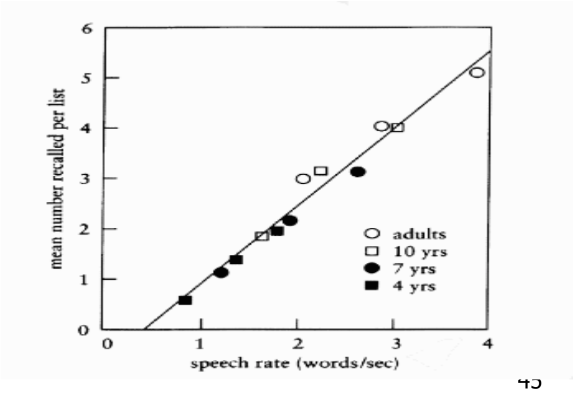
# Working Memory



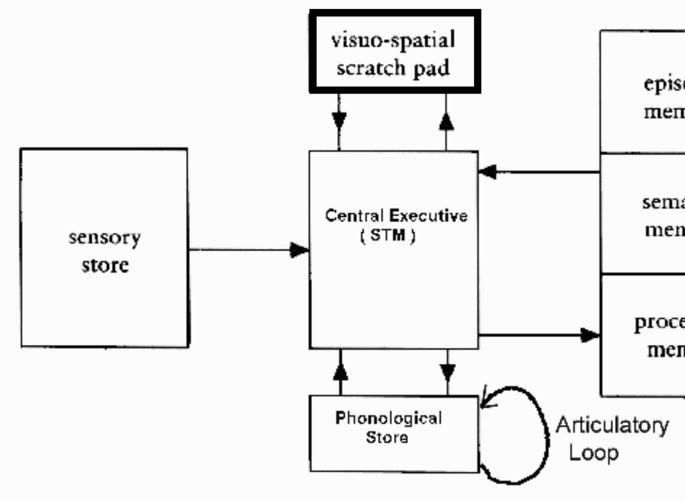
Baddeley’s Working Memory Model

# Phonological loop

- Holds on to speech information
- Silent speech ("articulatory loop") rehearses this information (can't use phonological loop while talking!)
- Capacity limited by how much can be rehearsed in a given amount of time.



# Working Memory



Baddeley's Working Memory Model

# Visuospatial Sketchpad

"a system especially well adapted to the storage of spatial information, much as a pad of paper might be used to work out a geometric puzzle."
-- Baddely

- Orientation and planning of spatial tasks
- Visual imagination
    - Engineering
    - Architecture

# Pattern span tasks

- Test of **Visual** STM: Participant sees a grid with some squares filled in for 3 seconds.
    - Must then immediately reproduce the grid
    - Grid increases to the size of visual span, and performance drops off
    - Mean performance (healthy adults) is ~9 filled squares

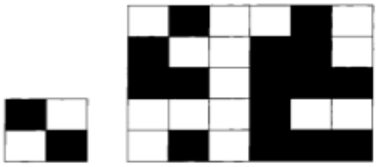


Fig. 1. Examples of simple and complex matrix patterns from the Visual Patterns Test.

# Using the visuospatial scratch pad

| | | | | |
|---|---|---|---|---|
| | * | | | |
| | | | | |
| | | | | |

---

# Using the visuospatial scratch pad

| | | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| 9 | 8 | 7 | 4 | |
| | | 6 | 5 | |

# Using the visuospatial scratch pad

| | | | | |
|---|---|---|---|---|
| | | | | |
| | 1 | 2 | 3 | |
| 9 | 8 | 7 | 4 | |
| | | 6 | 5 | |

People generally perform this task more accurately with their eyes closed than when they are looking at something.

# Summary: Working memory

- Has various parts: auditory, visual, spatial.
- Each part has a limited capacity.
- Central executive controls how memory is used.

- Tasks that require the same memory resources will compete for access.
- Tasks that use different memory resources will generally not compete (though will both go through the central executive).

# Conclusions

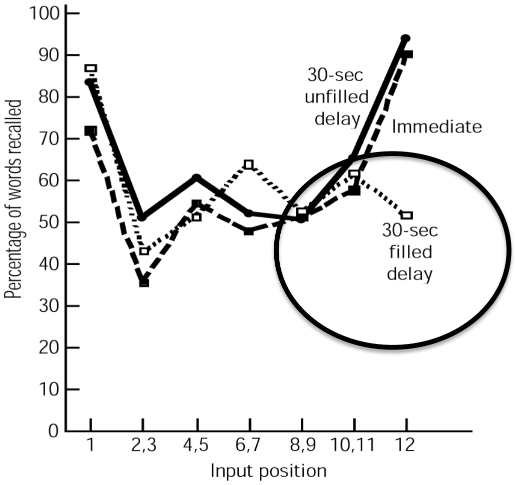
- Short-term (or working) memory:
  - is a critical interface between sensory information and long-term memory.
  - allows us to keep information available during processing.
  - is extremely important for most everyday tasks (reading, planning, problem solving, etc.)
  - has a limited capacity (which can vary across individuals).

# Thought question

In a typical short term memory task in which participants have to immediately recall a list of words, what would you expect to happen to the serial position curve if you introduce a short delay between the end of the list and the participant beginning their recall?

# Recency Effect

Serial Position Curve



Filled Delay Manipulation:

..train teacup kitchen typewriter racquet daffodil atlas…

[count backwards]

--recall--